School Science

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THE FRUITS OF SCIENCE TEACHING.*

BY ALBERT PERRY BRIGHAM.

Professor of Geology in Colgate University.

I have often said to young men in college, if you do not want to toil, keep out of the teaching of science. But if you choose it, remember that you will always be climbing over mountains of work. You will soil your hands on something every day; you will always be looking for something, breaking something, arranging something; you will often try to make one dollar do the work of fifty, and will congratulate yourself upon every hint that your needs are appreciated by principals, superintendents and boards of education. If you succeed thus in getting the sinews of your warfare, your fellow teachers of the humanities will some of them envy your riches and complain that every dollar you spend for a microscope is not given them for books. They will quietly forget that you need books as much as they, that you need room to put things, free afternoons for field excursions, double periods for laboratory work, and that while they walk into the class room with their book-bag under their arm, when the bell strikes, you have been there for an hour arranging your experiments or displaying your specimens; and that when they walk out at the end of the hour, you stay and put things to rights.

I am not inviting you to complain of your lot, for you have your peculiar compensations. One of the great reasons why you come together in such a meeting as this is that you may learn how to set up the machinery of science teaching and run it with least

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friction, having all the time in view the quality of your output. You compare notes that you may best order your themes, may effectively equip a laboratory, and then do your best with boys and girls in the lecture and in the practical exercise.

There is, therefore, little fear but that modern teachers will in the end know what they need to know and do what they ought to do. All that you do here, especially in your section meetings, will be to this end. But there is some danger that in our very proper devotion to technique and daily method we shall lose sight of weighty and inspiring things. There are high and inclusive principles and objects that should furnish the background, and, indeed, the very atmosphere of our toil.

Why do we teach science? Can we do something with our chosen instrument that teachers of language or mathematics or history can not do? And what is that something? Are we enough mindful of the higher ends of our work to keep us from treading a mill, holding down not merely our own, but the gaze of our youth to smaller and lower things, and shutting ourselves from the highest satisfactions that belong to our calling?

Barring some inherited tendencies the child enters the world as ignorant in the twentieth century as if he had been born in the tenth. Parents and teachers must succeed in handing on to him the whole harvest of the race. In this vast work it is our part to bring him into true and useful relations to the things and the forces that lie about him, to the whole world in which he lives. He is bound to learn that things have weight and that some things are heavier than others, but we must give him higher views about the weight of things than the grocery boy has. He will see the sun and enjoy the moon's light, but we must lead him into the heart of these primal facts of his environment. We must not leave him to the mercy of those who serve him when he comes to the ventilation of his house, to the installation of electric lights or to the dreadful mysteries of plumbing. The teacher of physics is short of results if he has only got some note books filled and has not led the boy to relate his science to common life.

Thus also the teacher of biology has his field and nowhere

greater than in the bearing of his science on the practical problems of disease and medicine. He is not specially concerned about making doctors, but he is creating a demand for the highest medical skill and an appreciation of it when it is offered. It is on such demand and such appreciation that we find established the growing endowments of medical schools and the extension of requirements for the medical degree. A convention recently gathered in a town which had suffered from typhoid fever. These people, mostly, no doubt, but moderately educated, would not touch the water, notwithstanding all assurances. Teachers of science can aid enormously in this crusade for pure water, pure ice and pure milk.

Here, too, we lend our aid for all forms of sanitation; we can give a rational understanding of the diseases and pests incident to plant life and can help our boys and girls to know, enjoy, and—all mushy sentiment apart—to love, our common birds, insects, flowers and trees.

If we are teaching geology we are still in the field of common interests. We expect our architect to advise us in the choice of stone, but we should know enough, it may be, to veto his decision, or if not, to value the advantages of what we accept. We can not lay the stone, but we know enough of stone to forbid the builder to put sedimentary blocks on their edges. The dressed blocks indeed will not make so much facing, but we shall know that our wall is stronger and we shall not be offended by the sight of blocks set in other than the natural and, shall I say, comfortable attitude which they had in the quarry.

You will so enlighten your boy that if he should be elected a road master he will not spend the money of the town in dumping soft shales on the roadway, only to afford a deeper slough after a year of weathering. And your commissioner will have some appreciation of the power of water and of frost and of the need of drainage. Your farmer, too, will not view the soil as something that has covered the face of the earth from eternity, but as a mantle derived through long and patient processes from the rocks and growing plants, as something, therefore, which can not be replaced and must be sacredly preserved.

If he know something of chemistry, also, he will appreciate the meaning of his rotations of crops, he will be able to adapt his fertilizer to his fields and he can reap a proper harvest of practical knowledge from the swiftly growing literature of the farm.

And if we give our young man a fair knowledge of chemistry he will have appreciation of many other common things, of much of the food he eats, of the drugs he buys and of a host of substances and technical processes that lie in the circle of his daily reading.

If we teach geography we open a world of things to young men and women. They go forth and the forms of the land are no more unseen, or looked on as enigmas. They trace the sequence of cause and effect in the homes, food, clothing, sports and crafts of men. They follow the paths of discovery, the routes of transportation, the building of cities and the growth of manifold industries in the long course of adjustment of every group of men to their patch of earth. The whole background of history and half the meaning of human life is open to the student of geography who comes to it not as a device for remembering places and boundaries, but as dealing with the environment of our race. Cloud and rainfall, frost and heat, storm and sunshine are written in living letters on every page of the open book which he will study throughout his life.

And when the air has been navigated, and telephone messages sent across the sea, and the north pole has been found, and the fiercest germ diseases have been robbed of their terrors, and communication opened with Mars, it will all be due to a new or more wise application of those same majestic principles of science which it is our privilege to unfold to our students.

But we go far beyond the mere convenience of knowing and using the material things around us. Above these practical uses is the uplifting and intellectual satisfaction of knowing the ways of nature in these great realms. The dullness of the world vanishes and familiar things are made real—are made over, and transfigured with fresh interest. The spirit of inquiry is at once aroused and satisfied.

I can not remember that in my boyhood I ever raised a

question about the drift bowlders, including the abundant "hardheads," of western New York. Nobody stirred up inquiry and my mind, open enough to Latin, was closed to nature. When I went to college one teacher began at once to arouse and satisfy thoughts of the world in which I was beginning to live. It is criminal in the twentieth century to let an intelligent boy become of age without knowing the commonest things that are out of doors. Better even the cranky certainty of the correspondent of the *New York Times,* who recently avowed that there never was a glacial invasion, or the well meant reply of an amateur believer in ice, who brought our late ice sheet down from the pole in good old style.

How much do you add to the solid pleasure of the man whom you enable to see in long perspective the work of the winds, as he rounds the head of Lake Michigan and observes the sand heaps and their scrubby trees, sees in his mind's eye the age-long crash of storm waves on the shores of the lake, sees, in a word, the physical history of the belt where prairie and great waters meet? How do you enlarge the life of the man of business if you give him the key of knowledge, and let him look from his office window in one of your tall human hives, to where the old beaches of Lake Chicago run. It will save him from some of the dullness of his routine life if he knows that man has only caused ancient courses of the waters to be renewed, that what the drainage canal does was done long ago without human aid, and perhaps without human observation.

And I do not believe it would spoil a man of business if he should like to go out to one of your quarries and stand on a floor of Niagara limestone and speculate upon that ancient wilderness of waters in whose bottoms crawled the trilobites, where the crinoids reared their wiry stalks in spreading fields and the corals opened their flower-like circles beneath the waves.

But I hasten to deny that the earth sciences have a greater glory of enlarging truth than the others. I only live in that field and know it best.

It is not easy to teach some boys how to use a microscope, to help them find the elusive little creatures in the field and get them to see and draw for themselves. But there come moments

of exaltation and triumph, when the dullest becomes alert, and elements of activity, or of form, appeal to the deepest enthusiasm.

I do not suppose it is easy or would be wise to give physics the interest of an absorbing story. The routine of careful manipulation, or of precise measurement is not less good because not exciting. The mathematics of optics may not be the delight of a boy, but the rainbow ought not to be less beautiful, but rather the more glorious, because the laws of light are known to him who sees it.

Nowhere can we put more perennial satisfaction into the life of a boy or girl than by teaching the main principles shown in weather and climate. Scarcely more close to us is food or dwelling, than the round of atmospheric changes, and when we make these changes march in orderly procession and interpret seasons, nights and days, dew and snow, cold waves and torrid heats, the clouds and the colors of the sky, we save the youth forever from mental poverty.

But there are higher ranges of mental, moral and spiritual training which you are privileged to reach. Science gives not merely useful things, does not only satisfy inquiry and serve our pleasure, she offers instruments of discipline and feeds the fires of the highest thought. I lately asserted, before a company of gentlemen engaged in business, that the spelling and general expression in our mother tongue were better than ever before. A school superintendent of large experience said at the close that I was right, and when I asked him how the good spelling came about without the old memoriter work, he said it was due to so much writing as is now required in schools. This throws light on our results. Concrete expression, in word and diagram, is the method of our teaching. We write deep into the tablets of memory without paying much attention to memory. Thus we give this important power the highest training possible, without wasting any time about it. We put the memory into normal activity in easy but lasting grip on real things. This solves the question of difficult terminology in chemistry or geology or geography. No terminology is hard for boys and girls that means something and is useful. All terminology is hard that means nothing and

is not useful. The moral is—use all the terminology you need and no more. Do not worry about remembered results if you are doing vital teaching, for, to paraphrase language used in a higher realm, the things that can not be forgotten will remain.

About the tritest thing we can say is that science work rouses and makes strong the power to see. But to quote experience in this field will not be trite. I conduct a class in topography and glacial geology, in the field, every spring term. We study the land forms and the land waste within a few miles of the college. It is rather familiar ground to all concerned. But it will not surprise you teachers to be told that every spring I see something in those valleys and on the hills that I never saw before. And I never cease to be surprised that seniors in college can't see the most blunt and staring terraces and flutings and drumlinoid curves until their attention is stimulated by questions or a bit of description.

The United States Geological Survey has a department of topography whose members go ahead of the geologists and make our contoured maps. Sometimes they do inaccurate work and the quadrangles have to be surveyed again. I have heard some one say, and with truth, that every topographer ought to be something of a geologist, for if he is not, he does not see the reason for land forms, and not seeing the meanings, he does not see them. It is certainly a fact that we must in some good measure know the causes before we can look out over the landscape and behold what is there.

How closely the imagination and the reason must work together in the pursuit of science. My assistant tells me that there is one question which he wishes the boys would not ask him, namely, how are kames formed. I agree with him. I do not like to be asked about kames. I am sure I never gave a good answer and I am equally sure that I never read a good one. But it is good mental exercise to restore an ice sheet to a region, to adapt it to the topography, to come down to the edge of it, to consider whether it was stagnant or active, how much waste it held, and how; where the waste came from, how the water behaved that came out of, or out from under, the glacier, what shape the de-

posits of waste took at different stages of melting, and what happened to them when the last ice melted from beneath the sands, gravels and clays. There lies before the mind a vague picture, seen as through a glass darkly; we have come up on this side and on that, but we have not described, sharply, precisely, with truth, the making of kames. But we have put the reasoning processes through a good course of sprouts, and we have taxed the imagination to restore from shreds and bits ancient conditions, and to try to bring out in color and perspective a picture that we never saw. Is any educational process more splendid than this?

It is ever our privilege to lead our students gradually along to inductions of increasing certainty, as we gather larger and larger stores of facts, testing our theories as we go and coming out at last either sure that we know, or sure that we do not know. One result is educationally as good as the other and there is no higher lesson to learn than this, that he contributes to the solution of a problem, who gathers even a few of the facts honestly, and clears away some of the rubbish that others may build on his foundation. And as knowledge grows and a stock of fixed principles is accumulated, the student will begin to infer necessary consequences from some of these. He will be able to say that coal will never be found in the northern peninsula of Michigan, and there is no use of looking for trilobites in the strata of the Atlantic coastal plain. He will practice, himself, in other words, in the methods of deductive reasoning. Being convinced of the evolution of life he will feel sure that countless generations of pre-cambrian times existed, though the records are small. Convinced of the reality of glacial dams and glacial lakes, he will find a spillway, and will straightway go to find the deltas, spits and wave-cut beaches that ought to be found on that horizon.

If he lives in western New York he will learn of the glacial Finger Lakes and their southward drainage. He will see the waters, lower in level but vast in area, and draining westward into Lake Chicago and the gulf. He will see the Mohawk valley gradually opening from its ice dams, the easterly flowing glacial rivers and fossil Niagaras of central New York, Lake Iroquois and

Lake Algonquin, until through elevations and depressions and meltings and readjustments, the present conditions come to pass. In all this is reason and memory and observation and imagination.

It is ours to teach the order and the orderliness of this world, to show the certainties of law, that results are gained only through causes, and after long courses of waiting and patient unfolding. The boy who has watched the embryonic development of frog, or chick, or bean stalk, or oak tree, and has seen the same kind of germ follow the same lines of change, to the same adult species, will be fitted for larger convictions of the continuity of life, and it will not be difficult to show him that we reap what we sow. He has seen a crustacean in the Trenton limestone and another in today's market stall. He has learned that both belong to the same tribe though an eternity almost separates them. They are similar and they are different, and the one has in some general way descended from the other.

If it takes millions of years to bring about such modest ends as the finishing of a lobster, is it not worth while to spend a few years in the perfecting of character and in the doing of every good thing? Boys ought not to come to college without any sense of duration, without any notion of how long it takes to do things. But they do so come. When you first refer to long passages of time, even to such trivialities as ten or fifty thousand years, they smile a smile of wonder. They never heard of anything less youthful than Pharaoh or Adam. They thus have not learned to be patient in waiting for the ends of God or man and they can not expand in the presence of that vast perspective which belongs to him who has tried often, though in failure, to imagine millions of years, and who has followed the evolution of lands and of life from the cosmic dawn to the present age. No human records are moldy enough or old enough to exalt our conception of time. It is only the story written in the rocks and the records shining in the stars, that can do that.

With the precision and order taught in the quantitative processes of physics and chemistry, in the laws of astronomy and in the successions of heredity, there runs a contrasting principle—the infinite variety and endless gradations of nature. Acorns

all produce oaks but no two oaks are quite the same, and with different soils and climate, may become quite unlike. It is not so fashionable as it once was to fill a text book, especially its front pages, with definitions. It is not easy to make definitions. It is easy to make definitions lie. The more we know the harder it is to make definitions. Let us tell out the facts of nature in as much order as we can use, and the definition will almost make itself. And some things are worse than to leave it unmade. The botanist, Asa Gray, writes to one of his correspondents, perhaps it was Darwin, about "that rascally genus," the aster. The asters would not fall into line; they would not fit definitions, they went their own way and did as they pleased. They had a family likeness, but the cousinships would not show up. There were no old parish records to clear up the genealogy.

Everybody ought to study some group of similar facts till he learns the lesson of individuality. That will tend to make him modest, to withhold and weigh his opinions of things and of men, to make him temperate, trustworthy and charitable.

There is a class of good men in this world. But no man is all good and possibly no two men are equally good. The same man seems better at one time than he does at another and society sometimes seems better and sometimes worse than its individuals. When we see the stern ongoing of law and cause in our heredity, and the strange mixture and surprises that creep in through the same door, we are prepared to approach with caution and modesty the problems of our life, to be at once severe and patient with ourselves and with all others. I am not saying that we should draw these moral lessons and preach them to our boys and girls. We should have sense enough not to do that. But we are fixing habits of thought that will transfer the thinker from the material to the spiritual, and he will look at things with truth though he may never know why he does it or who taught him to do it.

There is no machinery in our education outside of science for enlarging our ideas of space. The boy's native town, or at most his native country or state is all. He has heard of the greatness of the United States and foreign lands have been rumored

to him. But he has no notion of the width of the Atlantic, the Pacific is only a big lake and of the remoteness of the north pole from Iceland he never dreamed. He almost thinks with the ancient Hebrew that the lights of heaven are nearby in the firmament, and of the bewildering depths of the milky way he has never tried to think. As with time so with space, struggle with both fundamental ideas, through real studies of geography, geology, physics and astronomy, and you have lifted and made large the whole life, introducing, if there be any ordinary response, thoughts of humility, of modesty, of awe and reverence.

No fear is so baseless as the fear that our kind of teaching will foster low and materialistic views of things. Tyndall many years ago said: "Every attempt to restrict man to the dominion of the senses, has failed and will continue to fail." And yet he lived, we might almost say, with physical things, weighing, analyzing, explaining, things and forces. But how much could even Tyndall explain of the nature of light, or the deepest meaning of heat or electricity? How far toward the heart of things has the student gone when he has discovered and drawn his amoeba, his infusorian, his diatom? What does he know about a cell because he has recognized its nucleus and compared its architecture with that of other cells? Does he know how it is made or what makes cells develop tissues? Has he ever answered, or will he ever get an answer, to a tithe of the questions that he or his teacher could raise? He has touched the fringe of truth only, but into its mystery, its very sanctuary, he has not pushed his way. Is there a moral element, yes rather a spiritual experience in this? It is the lesson of mystery, of wisdom that lifts and draws us while it baffles us, that challenges the deepest and highest things within us, and goes far to give us a conviction of a something that for lack of better name we call the spiritual world.

To sum it up, our field is truth, not all truth, not all of the highest truth, but it is our peculiar business to see real things just as they are and to report them just as we see them. We have no business to juggle or distort, or exaggerate or hide—the whole truth and nothing but the truth, and facts that more surely than figures will not lie—these are our stock in trade, and we

fall below our privilege if we are not lifted into an atmosphere of reality, where we take things just as they are, see facts without distortion and use them without bias. This is the mental and moral habit that the world needs, in law, in medicine, in politics, in business, in literature, in public address, in private conversation—simple, unswerving, incorruptible devotion to the true, and this is the habit that grows, silent and unseen, in all real study of the world and its forces. We bring young minds into contact with facts, facts that can not have two meanings, can not be disputed or put out of sight, and they learn to take things as they are, and not as they would like to have them. To find evidence, weigh it well and act on it without fear, this is the highest living. We can bring more of the next generation to do this, for we practice the youth in seeing and telling the truth, in the plastic period of his life.

We do, however, go much beyond the ends of pure discipline and general culture in our teaching. For a great and growing number we are laying the immediate foundations of professional training. We do not need to worry about practical ends. The laws and principles of the natural world are fruitful and will not fail to serve the comfort and welfare of men. Students of science may, if they can, study for the love of it, and with no reference to incomes and dividends and productive inventions. The applications of their abstract truths will care for themselves.

But it is yet true that we may do something in the college, and often even in the high school, towards making physicians, civil engineers, mining engineers, and practical chemists. And we can do this without debasing our education. It would take a wise man to make a definition of culture. We will not try it now. But if a man has culture he will not have it because he is accomplished in German and French or Latin and Greek. It will not be his because he has taken long courses in philosophy, or history or natural sciences. He will have something from all of these or most of them, but his knowledge will be co-ordinate and vital. He will hold all his knowledge in relation to man and his work. He will have trained judgment and be able to bring his gifts and gatherings to bear on the world's work.

We do not longer know a world of two horizons, an upper chamber where a select few, refined, gentle and dignified, live in the atmosphere of repose, and hand down the opinions which the multitude ought to hold; while that rougher host of hard headed, ready and practical men, trained in dynamo rooms, carpenter shops and in front of forges, or in the rough schools of the department store, the mill, of practical politics or the newspaper office, do the work of the age and beget its sturdy sons, despite all the academic theorizing of the educated class.

More than ever today toil and theory, culture and practice, working and thinking, are mixed, and gather tone and clearness from each other. Thinking is more real and doing is more discerning and the thinker and the doer are not dissevered persons, but one and the same. The hand, the mind, the eye and the spirit are trained together for the work of life. Hence we are not afraid of bread and butter education. We would not put the future electrical expert upon mathematics and physics alone, of course. We must give him symmetry, we will teach him English and German—Latin, if he will—and history and economics, but we will not give him five years of these with no electricity, from fear that he might have a loving and longing look toward his future career. We will try to give him such judicious interplay of truth as will make a man of him, growing from the first in balance and power. Ideas and principles are not so ghostly that we drive them out because we seek them as embodied and represented in concrete things.

It is an old and wise notion that education connects the child's thought with his experience, and his experience is largely with the more or less material facts of nature. Let us take heart and go on, teaching with might and main the great body of facts and principles that lie underneath medicine, agriculture, manufacturing and engineering. We shall not be increasing the world's stock of materialistic notions or materialized men.

And we shall, now and then, some of us, not all, have the unspeakable joy of drawing out, as by a magnet, from the common, dull mass, the glowing, keen spirit who will enter the world of science as a discoverer, almost a creator. The boy of unsus-

pected, but supreme powers, will get his impulse, his self interpretation, from us, or from nature through us. It is almost enough to be a life work, if we, by our devotion and our fresh vital spirit, find and bring out to the world the rare boy or girl whose powers but for us might have stayed in hiding, with loss to all men. We are likely not to know, at the time, what life we are stirring to its depths, and sometimes it will be the boy who failed in Latin and had bad times in French, whom his linguistic instructors turn over to you with a sigh of relief, welcoming you to make something of him if you can. And I have seen your boy, fleeing from syntax and even from equations, rise to freedom and power before his diploma receives its seal.

With all the poor work that weighs on the minds of progressive teachers, I believe the English tongue is better spoken and better written by our youths than by those of any previous age. We will not take all the credit of this good and improving state of things, but much is due to science. We can not untangle the strands of influence, for our time is impatient of long words, involved sentences and obscure notions. To see, know, describe and use, is the way of our time, the plain, simple way of science.

Clear thinking helps to simple speech and the attempt toward telling and pure idiom reacts on thought; good thought and good speech are provocative of each other. If one brought up, I mean in the school period, in the long words of Latin origin may offer his own experience, the steady practice of a teacher, unfolding and describing the facts of nature, feeling the darkness of other minds and trying to make phenomena so plain that they must stand in the morning sunlight, trying to put down exact things when he has gone into the field with his note book, if such experience may be quoted, I assert a growing love of short words, short sentences of unmistakable meaning, and of speech that attracts all attention to the thing and none to itself.

If we need incentive it is this—the greatest modern men of science, dealing with the deepest laws, have been often true models of style in their records of things and their unfolding of principles. The vigor of Huxley, the lustrous simplicity of Tyndall, the clear streams of Darwin and Agassiz, the poetic elo-

quence of Dutton and Powell, belong to literature in the highest sense. Whatever makes simple, honest, thorough seeing of real things, will give to human speech the ring and power of truth, and the class rooms of science ought to be the strongest helpers of our teachers of English.

I have not half told the possible things in science teaching. More than all others you have direct contact with your students. You are at their side in the laboratory, and if you find your work room partly under the open sky, you will get and give the thrill of personal interest in the rarest degree, with your best students. The laborious character of science teaching is half its glory. Lose no heart in your effort to get adequate teaching force, in driving home upon superintendents and school boards your need of equipment, always compelling conviction by cheerfully doing great things with the little you have. Do not mind silly remarks about picnics when you make a field trip. Do not tell what you would do with a laboratory. Do something, make something, break something, if you must, but be alive, if you belong to our fraternity.

In some ways we shall teach most, not this fact or that of nature, but by being in ourselves the very embodiments of the spirit of science, in clear seeing, industry and ready acceptance of truth, with the modesty of those who must leave much unknown. Thus out of our work will descend on our young men and women a wealth of truly moral power, a moral power indeed, of which we have no monopoly, but which I am glad to believe belongs north, south, east and west, to the American teacher.

PLANT PHYSIOLOGY FOR THE HIGH SCHOOL.

SECOND PAPER.

BY W. F. GANONG, PH. D.,

Professor of Botany in Smith College.

The first of these papers, in this journal for February, 1903 (Vol. II, p. 429), explained the object, proposed plan and topics of the series, and discussed the educational value and place, the useful books and the kinds of apparatus desirable for plant physiology in the high school. In brief, it is my aim to treat as clearly as I can from the teacher's point of view those fundamental topics in plant physiology indispensable to any good educational course in botany, leaving it to the teacher to apply this material after the manner dictated by his own best judgment.

Before entering upon the subject of the present paper, however, I would like to emphasize certain points which seem to me of the highest importance. First, while I have the greatest sympathy with any good work in botany, and while I realize fully the limitations under which most teachers have to work, I must say that I am decidedly convinced that any course in botany which does not include a treatment of the fundamental physiological topics is hopelessly incomplete, unrepresentative of the state of science, and defective in its groundwork. It must include the elements of physiology, or it is aborted; there is no alternative. And this is not a matter of personal opinion or choice; it is something which the state of the science has forced upon us. I hope the reader will not so misunderstand me as to suppose that I am advocating physiology in preference to other phases of the subject, for that is not the case; I am simply claiming for it that share of attention demanded both by its intrinsic importance and by its indispensability as a groundwork for the correct understanding of the other phases of the science.

Second, I would state that while I regard plant physiology as a difficult subject for high school pupils to understand (though it is wholly within their comprehension when properly taught), so far from viewing that as a reason why it should be omitted from a

high school course, I consider it a prime reason why it should be introduced. If high school education is aiming toward that goal which some of our colleges appear to regard as their ideal, namely, to use education as a means for keeping young people pleasantly and usefully occupied while passing from youth to maturity; or, if this science is introduced simply to help satisfy the growing public demand for scientific education, but is to be used in such a way as not to divert the student's attention and energy from his studies in the humanities and mathematics; or, if the teacher does not understand this subject and is unable or unwilling to learn it, then, in any of these cases, I agree that the physiology, with other matters of much difficulty, should be omitted, and only the easy parts of the subject used. But if education is to develop, strengthen and discipline the intellect, then is vigorous effort on the part of the student essential, and plant physiology offers one of the most useful of scientific disciplines, as it is one of the most illuminating of all the kinds of scientific knowledge.

Third, I desire to emphasize this point in connection with apparatus for plant physiology, that every effort should be made to obtain accurately-working apparatus convenient for the special purpose, while home-made or make-shift pieces should be used only when the better can not be had. I am well aware that anyone who may have read some of my earlier writings could cite very different opinions expressed by me in the past, but I can only declare what is my conviction now after further experience. Observation of many students is leading me to see that much of the time and energy spent by them in improvising apparatus, while not lost, is yet not profitably spent, for they are expended upon purely mechanical manipulation, leaving little opportunity for the study of phenomena in the plants. It is mechanics, sometimes of a valuable, often of a rather kindergartenish sort, but is not botany. But there is a much more important objection to improvised apparatus than this, namely, that the necessarily inexact and too often logically inconclusive results obtained from such make-shift apparatus inculcate a very wrong ideal of scientific work, an ideal which it is very difficult later to correct. The very soul of the scientific method is precision, and a loose method is wholly inconsistent with it and

misleading. It is for these reasons I have for the past year or two been directing my own work to the developing of more precise and convenient apparatus for physiological experimentation, to be especially manufactured for the purpose and to replace those adaptations of appliances made for other purposes of which our apparatus has hitherto largely consisted. Descriptions of these pieces will be found in the articles to follow.* Yet it is, without question, a fact that the home-made or make-shift apparatus is much better than none, and I shall also describe in these articles the best of such pieces known to me.

The general method of teaching plant physiology to large classes must necessarily be that of demonstration, and in the number of this journal for February, 1902, I have described my own procedure, with which I have had good results. In brief, it consists in four things: (1) in leading the students, partly through recalling their earlier knowledge and partly through new information, up to the point at which they see the logical need of the experiment; (2) in setting up the experiment *ab initio* before them, explaining first its general theory and then minutely the reason for every step; (3) in requiring the students to observe and record the results as if the experiment had been set up by them individually; (4) in securing from each student a full note-book record of the experiment, clearly setting forth (a) its object, (b) the methods and their theory, and appliances used, with sketches of the latter, (c) the exact results observed, (d) the general conclusions. These records are, of course, examined and criticised by the teacher.

This combination of the demonstration and individual method seems to me the only one practicable under usual conditions for elementary classes. For such demonstrations the apparatus used needs to be of considerable size, and I have had this use in mind in designing the new pieces later to be described. Furthermore, the method necessitates the obtaining of only a single piece or set for each experiment, and it can be used indefinitely. I have no doubt

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*In order to make these pieces generally available, The Bausch & Lomb Optical Co., Rochester, N. Y., has agreed to undertake their manufacture, and to offer them for sale at prices as low as possible. Further, this firm has also agreed to keep in stock all the materials, chemicals, tools, etc., needed for work in plant physiology, including the simple articles needed for constructing the home-made pieces.

that the time is at hand when every botanical laboratory will possess, as a matter of course, a proper equipment for its demonstration-experiments in plant physiology, precisely as it now has one or more microscopes. Indeed, so far as expense is concerned, the entire equipment need hardly cost more than a single good microscope.

I shall now take up with some fulness those fundamental physiological topics essential to a symmetrical general course in botany, and shall try to treat them strictly in accordance with their scientific and educational worth. The treatment, I may repeat, is primarily for the teacher, who may use the outlines and experiments with his pupils either in full, in part, or modified, as he finds best. I regard, however, a treatment as full and thorough as that here given for all of the topics as no more than the proper amount and kind of plant physiology for an elementary course in botany given in either of the two upper years of the high school where fair facilities are available and a competent teacher is in charge. Wherever practical limitations prevent its present attainment, it may form an ideal toward which to work.

2. PHOTOSYNTHESIS.

(Assimilation, in part; carbon assimilation; photosynthetic assimilation; food-manufacture.)

Of all the physiological processes of plants, this is by far the most important, not only because of its consequences to the life, even to the very existence, of both plants and animals, but also because of its fundamental effects upon plant-form and habit. It is, therefore, desirable to consider it first among the physiological topics.

The cardinal points in this process are the following:

(1). The prevalence of green among plants, constituting their most distinctive characteristic.

(2). The green (chlorophyll) distributed in plants in accordance with their exposure to light.

(3). In presence of chlorophyll and light, a special substance (typically a sugar, frequently transformed to starch) is made.

(4). This substance (the photosynthate) permanently adds substance to the green plant.

(5). It is the basis of all plant (and hence animal) substance and is the true plant food. [Food as a source of energy is treated later under Respiration.]

(6). It usually and typically has the composition, $C_6H_{12}O_6$, or some related formula.

(7). The source of the carbon supply is the carbon dioxide of the atmosphere; of the hydrogen and oxygen, it is the water absorbed by the plant.

(8). Oxygen is eliminated in the process, in the proportion $6\ (CO_2) + 6\ (H_2O) = C_6H_{12}O_6 + 6\ (O_2)$.

(9). The dissociation of the stable carbon dioxide or water (or both), implied by elimination of oxygen, requires expenditure of much energy.

(10). Chlorophyll transforms (and perhaps applies) the energy in light for this work.

Of these points, the Nos. 3, 4, 7, 8, 10 are to be studied by experiment; the others rest upon observation, or upon evidence to be supplied to the students.

The best methods I have been able to develop for treating these subjects are those now to be described. After the full treatment of the subject with the class, an outline is given them as a guide to the full exposition of the subject which they are required to make. This outline, substantially as used with my own students during the present year, here follows. They are college students, it is true, but they are all beginners, and many of them are freshmen, and hence little in advance of the upper years of the high school. The treatment of the entire matter in this outline occupies about a third of the time of the class for some four weeks, including an hour a week with the class assembled, about an hour a week for individual observation, drawing, etc., and about another hour of writing and study. They are, of course, studying at the same time the other structural subjects usual in a laboratory course.

[OUTLINE SUPPLIED TO STUDENTS.]

WHAT ARE THE ESSENTIAL FACTS AND PHENOMENA IN THE PROCESS OF PHOTOSYNTHESIS?

Using the following outline as a guide, write in your note books a concise account of photosynthesis, incorporating in their proper places clear accounts of the experiments.

Accounts of all experiments should bring out clearly,—

a. Object of the experiment.
b. Exact method adopted, and its theory, with description and sketches of the apparatus used, and reasons for the various steps.
c. Exact results as you see them.
d. Your conclusions.

The most distinctive and important characteristic of plants; where chlorophyll occurs in the plant, and its physical nature; differences observable between leaves kept in light and in darkness; substance formed in the light. These considerations suggest some very close connection between the formation of the substance formed in light, typified by starch, and the presence of light, and the question arises: *Is light indispensable to the formation of the substance (starch)?* This may be answered by Experiment 1.

EXPERIMENT 1. Cover a leaf of a green plant, previously kept for two days in the dark, with tin foil, leaving another beside it uncovered; also partially cover another leaf of the same plant with tin foil in which some pattern, matching above and below the leaf, has been cut. Expose this plant to bright light for an entire day, and at sunset remove the leaves, blanch them of chlorophyll in hot alcohol, and place them in a solution of iodine which will turn all starch blue and thus render it visible. Compare the results shown by the lighted and darkened leaves.

Nature and importance of the substance formed (photosynthate). This suggests that it is the source of increase of substance in the plant, and the question arises: *Does the formation of the photosynthate result in an increase of substance in the plant?* This may be answered by Experiment 2.

EXPERIMENT 2. Take three sets of 100 seeds of a small hardy plant and weigh them, making the weights equal. Grow two of the sets by water culture, one in light, and the other in darkness beside it, until the limit of growth has been reached in one or the other set. Then dry both sets with the set of seeds in a water bath until no more moisture comes off, and weigh the three sets, comparing carefully the weighings.

Composition of the photosynthate, and available sources of supply of the elements composing it. These facts suggest that the source of the indispensable carbon must be the carbon dioxide of the atmosphere, and the question arises: *Do plants in photosynthesis absorb carbon dioxide from the atmosphere?* This may be answered by Experiment 3.

EXPERIMENT 3. Enclose two similar green plants, or parts of them, in similar glass jars so arranged that a definite percentage of carbon dioxide may be added to the air of each, and a sample of the air may be removed at the close of the experiment for analysis. Expose one of the plants for a day to light and keep the other in darkness beside it. At sunset remove samples of the air from each, and test the percentage of carbon dioxide in each.

Comparison of the formula of the photosynthate with the formulæ of carbon dioxide and water. The surplus elements thus shown suggest the question: *Is oxygen eliminated in photosynthesis?* This may be answered by Experiment 4.

EXPERIMENT 4. For this the samples of air obtained in Experiment 3 are available. After applying the test for the percentage of carbon dioxide in that experiment, apply to the same tubes a test for the percentage of oxygen present.

The separation of free oxygen shows a dissociation of the stable carbon dioxide or water or both, which requires expenditure of much energy; the dependence of the process upon chlorophyll and light suggests that light may supply the energy through the intermediation of the chlorophyll, and the question arises: *Does chlorophyll in any way affect the energy in the sunlight?* This may be answered by Experiment 5.

EXPERIMENT 5. Prepare a clear alcoholic solution of chlorophyll, and by means of the spectroscope analyze the light passed through it in comparison with light not so passed, and note the necessary conclusion.

[End of the Outline.]

We shall now consider practical procedure leading up to the use of the foregoing outline, the manipulation of the experiments, and diverse related matters.

(To be continued.)

THE COLLEGE REQUIREMENT IN CHEMISTRY FROM THE HIGH SCHOOL STANDPOINT.*

BY LYMAN G. SMITH,

Instructor in Chemistry, Roxbury High School, Boston.

At the present time, under the rapid extension of the elective system, chemistry has come into great favor, and laboratories and other facilities have multiplied to keep pace with the increase of students of the subject. In some cases this has been at the expense of other electives, notably physics. Indeed, this useful and fundamental branch of science has in some schools and colleges been almost deserted because of the crowding of the chemistry courses. Chemistry offers the best opportunity for individual laboratory study, with less necessary restraint than is required in the ordinary class room. But, above all, the chief excellence in chemistry lies in its power to give pupils practice in the very noble accomplishment of learning to think.

Chemistry should be learned by laboratory practice, expressed in a laboratory record. Both the work and the thinking should be done by the pupil. He should be led up to the proper point, his curiosity should be stimulated, and his efforts encouraged by instruction from the teacher, who must point out clearly what is to be sought, and give such hints as will be necessary for the successful performance of the experiment. After this encourage the pupil to stand on his own feet. Guide him and lead him but never push him. If you do so he will soon expect to be picked up and carried bodily, thereby losing that very exercise which is so essential. The cultivation of keen power of observation, and the ability to form wise judgments is the best preparation for life, as well as for higher courses in college. Such training will be sure to teach a great many of the facts of chemistry directly, and many more will come from the teacher indirectly. It is remarkable to find the large number of common substances with which a pupil becomes personally acquainted in a course of

* Abstract of a paper read before the Science Department of the National Educational Association at its meeting in Boston, July 10, 1903.

inductive laboratory work. It is the most thorough kind of chemistry study.

What are the practical points to be carried out? What material should be selected from the broad fields of chemical science? A real laboratory record kept by the pupil is the first necessity. In making this record it should be particularly emphasized that the essence of all laboratory work is honesty. For this reason it may be proper to overlook other defects until the pupil has become familiar with this true scientific spirit. The honest pursuit of laboratory study may often be aided by insisting upon having each period of work carefully dated, and by using note books with leaves which can be neither removed nor inserted. It is very important that all notes, even records of failures, be preserved and frankly exhibited. It is well for beginners to keep their note books in the laboratory, and to make all notes in the environment of their work. To prevent confusion between such laboratory records and memoranda made primarily for future reference, it is well to keep another note book for lecture notes and material such as a pupil may obtain from reference books or from the teacher. While this second book is valuable, yet it must always be held subordinate to the laboratory record, and the separate and distinct purposes of these two books should always be kept clearly in mind. To learn to take notes of lectures, or of reading, is useful, and may well be cultivated in the high school. It is not out of place even to give some instruction on this point, and occasionally to examine and to criticise such notes; but laboratory records should, for the most part, be examined in the laboratory in the presence of the pupil and his laboratory surroundings. A pile of books collected at intervals and laboriously examined, and then returned, yield but poor results, for the criticisms are in most cases either misunderstood or neglected.

Next to the laboratory record and the discussion in the class room the best method of stimulating thought is a written examination, or a laboratory examination. This valuable kind of review, often disguised under such euphemisms as "written exercise," "written recitation," and "test," is becoming seriously neglected. From its abuse we have come to overlook its value. Over-

worked teachers and indulgent parents have failed to recognize the advantages of even an occasional strenuous effort. That is the very best kind of training which teaches our boys and girls to meet and to overcome difficulties.

The text book plays no essential part in this scheme of instruction. It is to the authors of text books that we owe the planting of the study of chemistry in the secondary schools of this country. But former methods, which had to instruct the teacher, as well as the pupil, have now ceased to be effective. Authors of the best of text books have, with commendable generosity, admitted that their books do not express their own high ideals. Publishers demand books that sell. Teachers lean on text books instead of improving their own knowledge by study. Pupils learn to depend on the book to such an extent that it becomes unnecessary to pay attention to the personal instruction of the teacher. But, above all, at the beginning, the ordinary text book would be as inappropriate for this method of teaching chemistry as a key would be in algebra. Text books and drill books are useful for review and for practice in problems, but most of the drill work, as well as laboratory directions, can be printed on one of the very numerous and convenient duplicating machines now to be had at low cost. Most of the information in text books can be better impressed by using numerous wall charts made by the teacher or pupil, by excursions to such manufacturing plants as illustrate chemical processes, and particularly by instructively arranged and easily accessible collections of models and chemical products. These accessories accumulate rapidly in any laboratory, if a little attention is given to obtaining the necessary material. To profit by the peculiar value of chemistry as a high school subject we must realize that the actual study of chemistry must be done in the laboratory. If chemistry teachers continue to demand more time in school hours for laboratory work, and they ought to have it, they can not expect to require more than occasional home study.

During the first year or two it is hardly worth while to devote much time to the study of qualitative analysis. With the pupil's scanty knowledge of descriptive chemistry, and of those

laws which govern chemical reactions, the scheme of separation and identification is meaningless, and is performed mechanically. It is an exciting game, which keeps him industriously at work, but like much of the "busy work" in lower grades, it is of indifferent educational value. Qualitative analysis is a very long and insecure path on which to reach descriptive chemistry. It is not uncommon for pupils to pass through a score or two of "unknowns," with the impression that barium chloride and silver nitrate are both liquids.

In these days when not only milk, kerosene oil, and hay are either measured or weighed, but also heat, power, gas, water, electricity and almost the very air we breathe, and when anthropometry is an established practice, it is natural to follow this exact spirit of our time. It is certainly not worth while for pupils to waste days over wearisome determinations depending upon accuracy as their chief end. Yet every student of elementary chemistry ought to be able to handle a "horn" balance, and weigh a mass of a few grams to the second place of decimals. He should be taught the significance of the zero in such a quantity as twenty-hundredths (0.20) of a gram. Moreover, he should come to learn that the balance can answer many questions concerning those laws which govern the formation of chemical substances. Above all, let him learn to respect the balance as a useful and reliable scientific instrument.

The theories and the experiments relating to physical chemistry may seem difficult for a beginner. Nevertheless, the underlying Principles of the Dissociation Hypothesis and of the Mass Law are very fundamental. They are certainly as essential to a course in elementary as is the Law of Definite Proportions or Avogadro's Rule. The whole organism of the science is so affected by these theories, that without them the subject loses its significance. Teach theory as a means of stimulating the pupil to explain to himself the constantly occurring enigmas of nature.

In order to teach chemistry as a coherent subject it is necessary to avoid rambling in other fields. The applications of chemistry to cookery, biology, sanitary science, or geology and mineralogy, should be carefully subordinated to the general plan,

and used only so far as they illustrate chemistry. These other subjects should all be taught in the high school, but usually as separate courses. Except in very small schools, where it is necessary to combine subjects, chemistry teachers would do well to exert as much influence as possible toward the introduction of separate courses in industrial and sanitary science. Have them in addition to chemistry, but do not rob chemistry to make room for them. The teacher's skill should always be directed toward framing a well organized course of instruction, well defined in every detail, with each part well proportioned and intimately related.

But where shall we find material for such a course of instruction? Text books and college requirements suggest the main topics. We should teach the chemistry of familiar substances and their related compounds, about half a dozen elements, and the important compounds of a dozen more, including carbon. There should be some quantitative experiments, and the main principles of theoretical and physical chemistry should be introduced. The Boston chemistry teachers, meeting in the laboratory of Miss Laura B. White of the Girls' High School, prepared two years ago a course based largely on the Harvard requirement. Several Boston teachers have since been using this with satisfaction, either in whole or in part, although the text has never been put into print. The Harvard Requirement, published by the University, is sent on application, free, to teachers only. The circular of the College Entrance Examination Board is also an excellent guide. Printed notes like Miss White's *Chemical Theory*, a modest but useful pamphlet, may furnish excellent material for fastening principles which have previously been worked out in the laboratory.

The advocates of inductive teaching have frequently been told that it is absurd to try to make children do research. This is a misunderstanding of the situation. If Archimedes had been furnished with a "J" tube and a bottle of mercury, not to mention the instructions of a patient teacher at his elbow, the familiar law governing the relation of the volume and pressure of gases would not have had to wait for Robert Boyle. The exploration of new fields is of quite a different order of difficulty.

The crying demand of the intelligent critic is for specific education. We are just now burdened with much pseudo-education. No person can learn the chemistry of silicon by washing windows, any more than he can learn the chemistry of alcohol by drinking it. Does your experiment teach anything? If so, is it really worth teaching? Are you training pupils toward self-reliance? Are you cultivating mainly the imitative or are you cultivating the constructive and inventive faculties? How does your pupil act when he encounters obstacles? Do you ever bring to light a genius? It is a hopeful sign that each year the new education is sending out into the world not a few persons capable of original work in some field.

Above all a teacher of chemistry should be definite in his aims. Having decided on a policy pursue it without hesitation, and long enough to gain familiarity and efficiency in teaching the course. Remember that a poor method and a good teacher is far superior to a good method in the hands of a poor teacher. But seek to attain the supreme result in both good teaching and a good method. Insist on the spirit of scientific integrity. Give the same instruction to all the members of the class. It is a most pernicious practice to put a few choice souls into a separate division, just because they are going to college. Give your best instruction to every pupil. If he has done his work successfully in school, he will be able to pass any reasonable examination for college.

A wise prophet as well as a distinguished American statesman has recently told us that the test of all education's worth is that "it induces the will to adhere to its general, permanent and deliberately conceived purpose, in spite of the motives which appeal to it with special strength at the time of choice of action."

We may also apply Dr. Sargent's test of physical efficiency to our chemistry teaching, and ask of ourselves concerning each pupil, What can he do? How well can he do it? How long can he keep at it?

We must not forget that we are training boys and girls for the responsibilities of democracy, where intelligence, discriminating judgment, deliberate action, continuous labor, and sturdy integrity mean enduring liberty.

ON THE FIELD TRIP.

BY GEO. D. HUBBARD,

Cornell University, Ithaca, N. Y.

The changes in subject matter in a number of our school and college courses and the new courses offered have added a new perplexity to the teacher's list. Botany, zoölogy, agriculture, nature study, physiography, commercial geography, geology and even arithmetic and sketching are calling for field trips, or opportunity for outdoor study of the things read about on the page or seen in pictures. Most of our teachers never heard of such field trips, much less ever made any, when they were students. If as observing as they should be, however, they have seen the common plants and animals, and have noted some of nature's changes. They have visited a factory, a wharf, a river, beach or mountain, have measured a corn crib or a floor for a carpet, but to put a class through these exercises is, apparently, not considered an easy matter. A variety of difficulties arise and try to interfere with the enterprise.

In the first place the class must be orderly, if any thing is to be learned on the trip. Sometimes the pupils must be cared for in mills or in parks or forest where a dozen things might injure the careless or venturesome meddler, or be injured by him. The attention must be held and usually the class kept together even though new and diverse things attract the individuals. Then honest work must be done. If pupils are allowed merely to kill time or to talk and prattle of things unrelated to the excursion, valuable time is lost, and the pupil is really worse off than when the trip began.

Then there is the business end, the assembling of the class, providing transportation and obtaining permits. Since this end of the program comes first, here is a good place to begin answering some of the questions arising when an educational excursion is planned.

It should be understood that the trip is as much a part of the work as is the recitation, and usually that a written or verbal report of things seen is as important as is a review or sum-

mary of some assigned reading. These understandings if followed up by starting on time and gathering up the reports when due, not only furnish training in promptness in the first case and in English in the second, but they add dignity to the excursion, make its government easier, and give the pupil a goal to attain from the very beginning. He goes out knowing that his standing depends in part upon what he brings back and embodies in his report. Promptness in starting and conformity to a program during the trip add very much to the comfort as well as to the profit. The pupils need not know much of the program, but they must realize that there is one.

The comfort of the members of the class must be considered and allowed to guide to some extent. When the purpose of the excursion can be as well served, the meadows, fields and lake or river side should be seen in the afternoon instead of in the morning while the dew is on the grass and shrubs. Advise with the class as to lunch, clothing, and wraps that will be needed. Large parties are always to be avoided. Only a limited number can see and hear during the open air demonstration, and the teacher can not supervise personally more than a small number. The size of the party may be determined by the number meeting together for quiz and recitation work or for laboratory exercises. Twenty makes a good number for a field party. A smaller number is better than a larger.

Now for the real mission of the excursion. The class is out to learn, to collect, or to catch an inspiration. The teacher must be doing and must be enthusiastic. His own industry, not his wisdom, will inspire the excursionists. Jesting, joking, punning and making irrelevant remarks will not inspire the class if it does keep them jolly. No class needs these things.

Each pupil should have some definite thing or things to see or study. All may work on the same question or, where possible, each on a separate one. The teacher may select the problems, suggest them or let the pupil find them according to the stage of the pupil's knowledge, and, consequently, the ease with which they can be found. Let the pupil state his problem in his note book and then enter upon its solution. Nothing can be done until he

has a clear notion of what he is going to do. His first duty, then, always, is to state his problem. This done many of the difficulties are removed.

While the pupil is at work the teacher should let him alone. Follow his work closely enough to see that he is getting good results. Be ready to aid him but do not tell him things he ought to see. He may be questioned and suggestions may be given, but bear in mind that his interest increases in considerable measure when he can discover something himself. Some teachers have a "know it all" air, but it does no harm frankly to say, "I don't know." The wisest come to that on many points. Nothing so disgusts the pupil and lowers the teacher as dodging. Hedging may wisely be done, but don't pretend to know what you do not know. Out with it and take the consequences. If you should have known it the incident may do you good. If it was out of your reach the pupil will recognize that fact and you will have won instead of losing.

After the trip look over the reports, which have come in on a designated day, and then discuss them with the class, explaining common errors and asking pupils to explain rare ones. Maps, sketches, diagrams or even photographs may form a part of the report, which should go back to the pupil corrected. Suggest places to look up related facts or phenomena either for correlation or for comparison. Often it is wise to have the pupil reproduce his work, drawings and explanation, before the class, if others have not worked upon the same problem.

If possible, and it usually is, the teacher should have visited the place or gone over the excursion previous to doing so with the class. This will help him in making his program and in finding problems for the investigators. Where not possible to see first, advantage can of course be taken of other's seeing.

Excursions properly prepared for and systematically carried out need not be a bug-bear but a pleasure. The teacher feels himself grow as he increases his mastery of the subject, but his inspiration comes from seeing the pupils' intellectual stature increase in the new experiences and to witness the silent joy on his mental face as he grasps new truth.

THE CAMERA AS AN AID IN ZOOLOGICAL INSTRUCTION

BY ALVIN DAVISON,
Professor of Biology, Lafayette College, Easton, Pa.

The ideas set forth in this article are the results of two years' experience with the camera, used for the purpose of bringing the student into closer touch with animal life and its environment, and thereby arousing within him a desire to know the relation of man to the animate world about him. Every instructor is well aware of the fact that the one thing most needful in teaching is to secure and hold the interest of the pupils. The great German pedagogue, Stande, says: "Interest is the light with which Herbart has once for all brought the dark and tortuous course of didactics into the clearness of day. It is the charmed word which alone gives power to instruction, to call the spirit of youth, and to make it serve the aim of the master."

Comprehending a subject obscurely never creates an abiding interest in it. The young receive more permanent knowledge through sight than through all the other senses combined. If what is concerned with the subject studied can not itself be observed, the best substitute is a true picture. In many cases it is impossible to have at hand all the stages in the life-history of an organism, or all the specimens with which the learner should become acquainted in order to acquire a nutritious understanding of the subject under discussion. Here is where the teacher with his camera productions should bring clearly before the class what he has observed in reference to the forms under consideration. In order to make plain the meaning of this statement, as well as to show what can be done by an amateur, a number of illustrations are given showing some of the stages in the metamorphosis of the seventeen-year locust (Cicada septendecim).

Owing to the fact that the normal transformation from the pupa or nymph state occurs only during the night, it was necessary to use flash lights. The clear definition characterizing most of the pictures was secured by focusing on a lighted match held just above the insect to be photographed. Figure 1 presents the results of the

first attempt I ever made to take a flash light picture. This was secured on the last Saturday night in May, 1902. The others (Fig.

Fig. 1.
Flash light near midnight showing six stages in the transformation of Cicada septendecim.

2) were made on the following Monday night. The plates used were Carbutt's rapid and Cramer's medium isochromatic. The lat-

ter gives the best average results in animal photography, and enables one to dispense with a color screen, except in dealing with a creature having pronounced orange or red tints such as the common lady bird beetle.

In order to photograph an animal natural size one must have a camera with a bellows of considerable length. The Long-focus Premo, which I use, has a bellows extension of three feet, whereby an object can be enlarged fifteen times or almost four diameters.

Figure 8 shows the results of my first effort to make a photograph of an animal life size or larger, and also furnishes proof of

1 2 3 4 5 6 7

Fig. 2.

1 Flash light of pupa at 8.50 p. m.: 2 at 9.15, (showing a slit in the shell); 3 at 9.20, (adult is protruding); 4 at 9.45, (adult is just out of the dark shell beneath it. Left wing is beginning to expand); 5 at 10.00, (wings expanding); 6 at 10.20, (wings more than half expanded); 7 at 10.30, (wings completed).

the fact that even a tyro may secure an enlarged picture of an object and at the same time have all parts in fairly good focus. The secret of securing this result is not so much in the quality of the lens as in the use of the diaphragm. The operator should focus with a wide-open diaphragm on the part nearest, or the special feature he desires to bring out clearly; then in exposing the plate use diaphragm 128 ($\frac{1}{8}$ inch aperture).

This necessitates a time exposure of twenty seconds even in bright sunlight, if the object is being enlarged three or four times. A fact to be remembered in photographing small things is that the more one is enlarging, the longer the time of exposure required. Figure 8 was taken in the bright sunshine of an October day at 11 a. m. with diaphragm 128. The plate was a medium isochromatic, and the time of exposure twenty-two seconds. Of course, only ani-

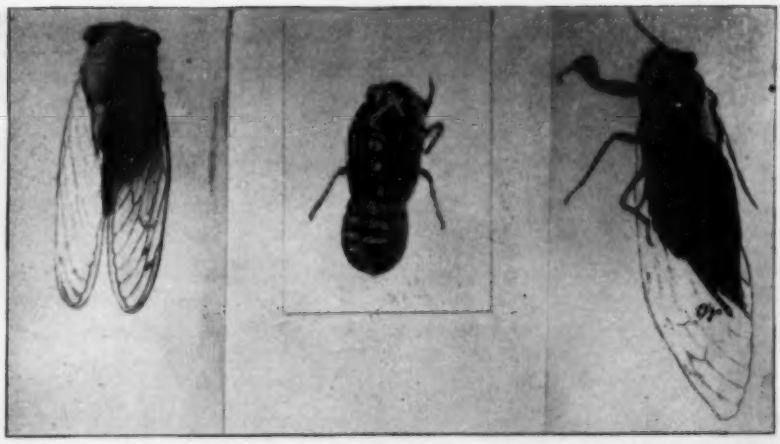

Fig. 3. Fig. 4. Fig. 5.

Fig. 3. Photograph of Cicada made by daylight showing the quick change from the creamy white color of midnight to the somber hue or day.

Fig. 4. Empty pupa shell of Cicada.

Fig. 5. Lateral aspect of Cicada with wing removed to show ovipositor, *ov*.

mals that will "freeze" can be thus treated. For many species it is necessary to use a rapid plate, and a diaphragm of wide aperture requiring only one second, or even less, to get a life size impression.

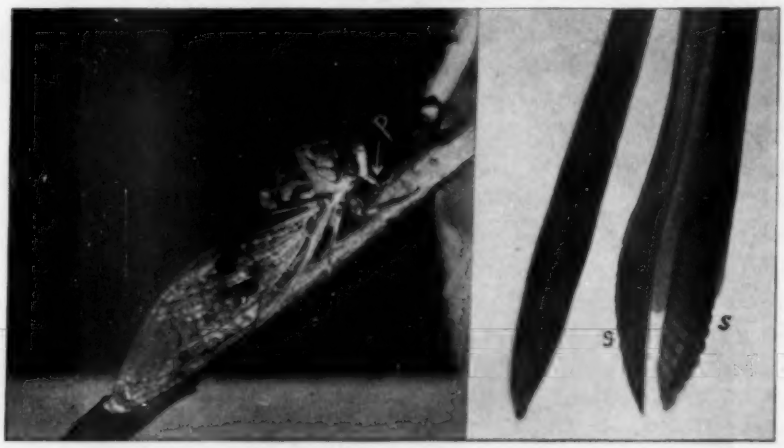

Fig. 6. Fig. 7.

Fig. 6. Photograph of the dog-day harvest fly (annual locust os Cicada tibicen) sucking juice from a twig. *P* is the proboscis.

Fig 7. Photo-micrograph of the terminal fourth of the ovipositor. *S S* are the saws used in making incision in twig for reception of eggs.

Fig. 8. Larvæ of an Arctian moth bearing five Ichneumon eggs.

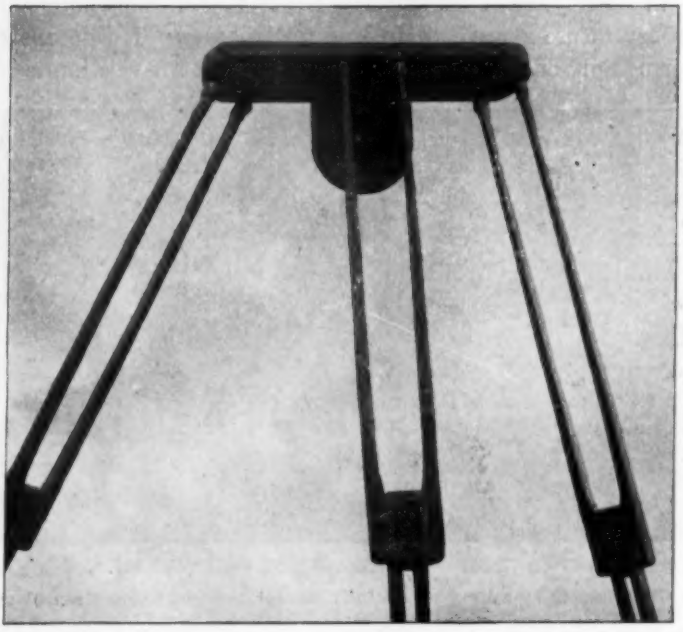

Fig. 9. Front view of a scientific tripod.

When the color screen is used, the time of exposure must be tripled.

The tripod is the only part of a scientific photographic equipment which must be made to order. In many instances the nature student will find a great convenience in such a tripod as shown in Figure 9, whereby he may point his camera in any conceivable direction. The top piece is of hardwood, one foot by four inches; the lateral support, four by five inches. To this head the legs of any ordinary tripod can be attached.

After the negative is made the teacher may follow either of two plans in bringing before the pupils the results of his animal studies. Ordinary prints may be made and given to the members of the class, or, what is far better and more quickly done, lantern slides may be easily made, and then the results brought before all eyes at once, thereby giving an added interest to the work.

If an animal is being photographed for the purpose of obtaining a lantern slide, the size of the picture should not be larger than 2¾ by 3 inches, so that the quickest and simplest methods of making the slides may be used. This is known as the contact method. A box of a dozen lantern slide plates costing 55 cents should be secured and opened only in the dark room, with the same precautions used in handling the ordinary sensitive photographic plates. The negative is placed in the printing frame, film side up, and on it a lantern slide plate, film side down. In other words, the films of the two plates are in apposition. Often one can not tell by the dim light of the dark room which is the film side of the lantern slide plates, but must rely on the fact that the plates are packed in pairs with the films in contact, so that the first slide taken from the box has its film side down and the next one its film side up. The next step is to replace the back of the printing frame, taking care not to displace the lantern slide plate, as the careless manipulator is liable to do, owing to the fact that the negative plate will, of course, always be the larger of the two. The printing on the lantern slide plate may be done in several ways. The entire frame may be held about three-fourths of a minute at a distance of ten feet from a 16-candle-power electric light, or eleven seconds at a distance of five feet. If an oil lamp is used, it should stand just outside of the dark room door, where the worker may step and hold his

printing frame before it for about one minute at a distance of four or five feet, provided the flame is one inch high by three-fourths of an inch wide. A smaller flame would, of course, require a longer time for printing. These periods of time are given for the average negative. A negative that is very thin would, of course, yield a print in much less time, while one very dense would require a longer time than stated above. A little experience will enable the amateur to determine by a glance at the negative the time necessary for printing a lantern slide from it.

When a slide is printed it may be kept in a box until others are printed, or developed at once in the same way, and with the same fluid used, in making an ordinary negative. It is better, however, to dilute the developer with one-half its amount of water, or still better results may be obtained by using the developer made by the formula found in the box of lantern slide plates purchased. As soon as the plate is developed, it should be rinsed and placed in the ordinary fixing bath of "hypo" for a few minutes, and then thoroughly washed for an hour. After drying, a cover glass should be placed over the film side, and the two plates of glass bound together by a strip of mucilaged paper, known in the market as a lantern slide strip. They may be purchased for about 10 cents per hundred. If the negatives are at hand, one can finish up in a week's time, by working two hours a day, more than one hundred lantern slides.

Among the numerous subjects that can be well presented to the wideawake youth are Protective Resemblances and Mimicry, Animal Communities and Social Life, Parasitism, Economic Uses of Birds, Useful Insects, Harmful Insects, Transformation in the Insect World, and Adaptation to Environment.

The instructor may supplement his lantern slides made from animals studied personally, by exchanging slides with other teachers who have made observations on other groups of animals, and also by making slides from pictures in various books on natural history. During the past two years I have made nearly two hundred good negatives showing life-history, habits, and environment of animals, and have thus been led to comprehend much in the animal world of which I should otherwise have remained ignorant. By exchange and purchase my list of slides has increased to nearly one thousand.

THE COLOR OF OBJECTS.

BY ARTHUR W. GRAY,

Berlin, Germany.

In nearly all of our elementary text books of physics the interesting subject of the color of objects is so inadequately treated that it does not seem out of place to describe here a few simple lecture experiments designed to bring out the principal phenomena involved in such a way as to be readily appreciated by the young mind. A clear experimental treatment is especially useful to correct some absolutely false impressions conveyed by several of our texts that enjoy a wide sale, and thereby to convince the pupil that not everything that appears in print is true.

The first step is, of course, to show that the color that an objects appears is determined largely by the color of the light that illuminates it. This may be well brought out by the stock experiment of holding various colored objects in the light of a large sodium flame, and in different parts of a bright spectrum thrown upon a white wall or screen. After it has been thoroughly appreciated that the simple colors that compose the color of the object must be present in the illuminating light, the pupils are liable to draw the erroneous conclusion that is so commonly stated or implied in the current texts, namely: that the body reflects these colors and not the others.

This impression may be corrected by showing that, when a bright beam of light is reflected from the surface of such bodies as colored glass, smooth paper, or copper sulphate solution so as to fall upon a white screen, the bright patch formed on the latter is not colored, but white. When, however, the white light is made to pass through a piece of red glass, the patch on the screen is red; and even if the transmitted beam be reflected from a piece of glass of another color, the patch will still be red. The other objects mentioned behave in a similar manner, showing that they *reflect* whatever colors fall upon them, but *transmit* only their own colors.*

*Those bodies whose surfaces are not polished must have the beam incident at a considerable angle if the reflected light is to form a readily visible patch on the screen. Highly colored glazed tissue paper tightly stretched by wetting and shrinking on a small wooden frame shows both reflection and transmission fairly well.

The next question to be settled is: How do these objects color the light that passes through them? Does a piece of red glass, for instance, add redness to the white beam? or does it subtract the other colors, leaving red as a residue? Holding the glass in the path of a beam which is decomposed by a prism into a spectrum will show that the latter is the case. With this evidence it is easy to build up the idea that in such cases as those shown the color is due to *selective absorption,* or, looked at from the opposite point of view, *selective transmission.* The light must pass through some of the object either on the way to or on the way from the surface that reflects it to the eye, even though the distance passed through be very minute, as is the case with powerful pigments. This notion may be emphasized with the aid of a piece of red glass whose rear surface has been silvered so as to reflect well the light that gets through to it. The reflected light will now form two overlapping patches on the wall, a white one due to the light reflected from the front surface, and a red one due to that which has passed through the glass and has been reflected out again from the silver.

But are we now justified in concluding that the color of an object is *always* due to selective absorption? Try reflecting white light from a piece of planished copper held so as to give a considerable angle of incidence, and preferably bent slightly concave so that the reflected light may be concentrated into a caustic curve. In this case the patch formed on a white screen is not white, but has a decidedly reddish tinge. The reflection from brass or from gold has a slightly yellow tinge. Is the color in the case of these metals due to *selective reflection?* Or does the light that is reflected from the very smooth portions of the surface manage to pass on its way through some minute projections, and thus still have its final color determined by *selective absorption?* We might, perhaps, be able to decide this question if we could obtain the metals thin enough to be transparent, so that we could compare the colors of the transmitted and the reflected light. This may be readily done by smoothly covering one-half of a microscope slide, or other piece of plate glass, with gold leaf, which will adhere if the surface of the former be very slightly oiled. Holding this in the

path of the white light, it is seen that the patch on the screen is bluish green when the light is passed through the gold, but pale yellow when reflected from its surface. The contrast between the part of the patch due to reflection from the gold and the part due to reflection from the neighboring uncovered portion of the glass brings out very clearly the yellow tinge of the former. With this evidence it is easy to develop the conception that, in some cases, notably in that of metals, the color that an object appears is determined largely by *selective reflection*, the object reflecting all colors to a certain extent, but some much better than others.

Another class of cases that may profitably be exhibited merely to show that sweeping generalizations must not be based on meager evidence, is that of fluorescent substances. But here care should be taken to avoid any attempt at giving an explanation of the phenomenon, since its adequate treatment would lead pupils of high school grade into matters that are entirely too deep for them. It is sufficient merely to show that when a beam of light is sent through one of these substances, a color appears in the interior that is different from that of the transmitted light. Very suitable substances are such common ones as kerosene, a freshly prepared alcoholic or ethereal infusion of green leaves, a solution of sulphate of quinine in water containing a little sulphuric acid, very dilute red ink, and many others. Red ink of ordinary strength shows a very strong dark green surface color, which does not seem to penetrate into the interior; with increasing dilution the color extends farther and farther inward; and when the dilution is sufficient, a beautiful bright green fluorescence marks the course of the beam within. As glass strongly absorbs that part of the radiation which causes the fluorescence, the walls of the containing vessel should be thin if the light is admitted from the side; but the better practice is to reflect it vertically downward directly into the liquid. Concentrating by means of a lens so that the focus falls within the body renders the phenomenon still more visible to a large audience.

Irridescence and other color effects due to interference or diffraction, are, of course, entirely outside the province of secondary school instruction.

AN APPARATUS FOR ILLUSTRATING LIQUID PRESSURE.

BY A. R. HAGAR.

Physical Laboratory, Manila (P. I.) Normal School.

While teaching physics in the Salt Lake City High School there were frequent questions of a practical nature asked by some of the boys, who had spent their vacations in the mines, which are the chief source of wealth of the region.

One of the boys, who had spent his summer in the vicinity of Park City came up to me one day with a question, as follows: There was a water power (Pelton wheel) located at the base of a mountain fed by a stream originating in the melting snow cap. Part way down, at the highest practicable point, a reservoir had been built, from which the water was brought by a flume to the wheel. The mine manager planned to build another reservoir or enlarge the present one to get *more pressure,* the second or enlarged reservoir to be built at the same altitude as the present one. The pupil said he "couldn't see how this would give any more pressure if the head didn't change, according to the law given in the text book—but still it did seem as though it ought to make some difference." Our high school demonstration equipment did not include a set of Pascal's vases, so we arranged an apparatus, shown in accompanying figure. This, I found, was very easily used and readily understood by the class. Of course, the receptacle Y, which is the neck of a broken retort, represented the present reservoir, and X the proposed large reservoir. The manometer, with mercury, shows by its level at H that the pressure from water in X, as shown when cock D is opened, is the same as pressure from water in Y when cock C is opened, or the same as pressure from both vessels, with both C and D opened. By adding a little water to Y, when both cocks are closed, and then opening cock C, the added pressure due to the greater head is easily shown. The pupil will see that if the levels of water in X and Y are the same that the pressure on surface B is the same in each case, but that if the water were running through a water wheel at B the pressure would be maintained for

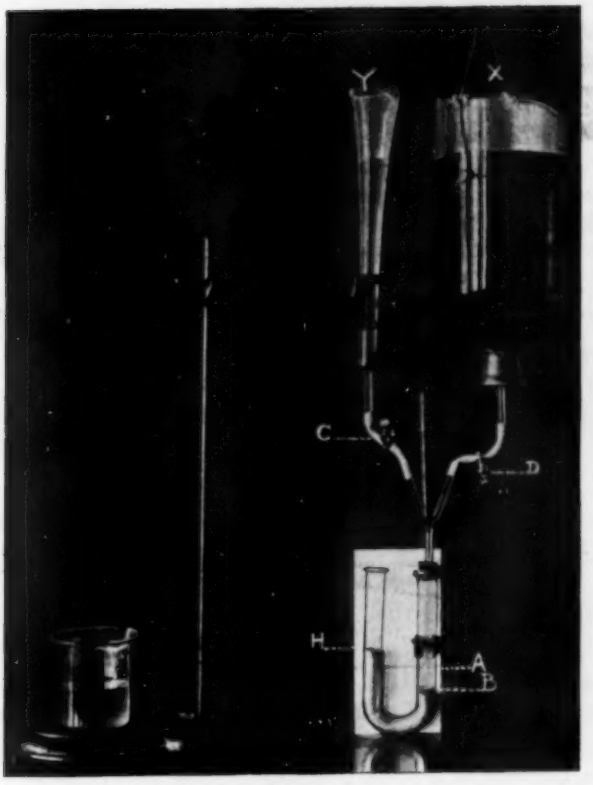

Fig. 1.

a *longer time* with a large *quantity* of water, that being the advantage of the large reservoir.

Metrology.*

OPPOSITION TO THE METRIC SYSTEM.

BY DR. WILLIAM H. SEAMAN.

(*Concluded from page 360.*)

We agree with the paper that the two systems of measures are not both going to exist side by side forever, and also that it is inadvisable to have the expressions in technical literature different from those in common use (653). The world is going to use all B. S. or all M. S. As the M. S. has acquired its present position of greater universality than any system ever had before in the face of the B. S., which in many cases it has displaced, it seems easy to see the direction in which things are moving. But it is said the manufacturing success of the English race is going to force their measures by means of their goods on the rest of the world. Against this we have the actual practice of the English race itself in all scientific matters, and it must be remembered that the arts follow science—they do not lead. Three-fourths of all those who become acquainted with the M. S. are in favor of it and are willing to work for it. It is alleged, for example, that United States capital is taking the mile and the foot into Mexico. Well, every time-table of a Mexican railway in any of the large hotels in our cities has kilometers on one side of it. If we are taking the mile into Mexico, Mexico is bringing the kilometer into the United States. In New Orleans, it is said, some French shops sell their dry goods by the meter. If our watches and fine tools are made by the M. S., if all our scientific work is done in M. S., in which fifty years ago it was almost unknown, it is evident the B. S. is not going abroad any faster than the M. S. is coming here, and it seems a piece of folly to attempt to turn back the march of progress in this direction to our own disadvantage, as it certainly is. The inconvenience of changing our screw threads, by which a small part of the population is affected, is as nothing

* Communications for the Department of Metrology should be sent to Rufus P. Williams, North Cambridge, Mass.

compared with the welfare of the entire community and all who are to come after us.

There is no difficulty whatever in planning and erecting buildings on the metric system at the present time. It is well known that the sizes of bricks, etc., vary somewhat in different places. The following tables are taken from actual measurements of building material made in Washington, D. C. The dimensions are in centimeters, and will be found to be actually more exact than if stated in inches.

The average brick is 22x10.5x6. Press brick are a little smaller, and soft brick a little larger, but the 6 cm. of thickness prevails with much constancy. In rough work, three joints, equal two cm, press work less; four and a half to five bricks lay a meter run, and fourteen to fifteen courses make a meter high, single thickness. A wall of two bricks wide is 22 cm., three bricks 35 cm., four bricks 45 cm., five bricks 60 cm.

It would be very advantageous if bricks were made 24x12x6 cm. Three joints rough work equal two cm; press brick lay closer. An average building block is 30x10x4.5; some are longer. It will take seventy bricks to a square meter in the wall. Loss and waste is 3 to 5 per cent. Bricks weigh three kilos apiece; building blocks less. The weight varies according as they are moist or dry; they will absorb much water. One part lime to two sand will give 2.4 volumes of mortar, one lime to three sand 3.2 volumes mortar. Cement with 1, 2 or 3 parts sand, gives respectively 1.25, 2.1 and 2.9 mortar.

To lay 1,000 bricks will require 0.75 of a cubic meter of mortar. The specific gravity of building material is as follows: By multiplying the volume by the specific gravity the weight of any volume is found.

	Spec. Grav.		Spec. Grav.
Dry sand	1.4 to 1.65	Sandstone	2.03
Moist sand	1.9 to 2.05	Granite	2.51 to 3.5
Coarse sand	1.4 to 1.5	Bricks	1.4 to 1.55
Stone lime	0.9 to 1.3	Hard bricks	1.6 to 2.
Slaked lime	1.15 to 1.25	Cork	0.24
Lime mortar	1.65	Willow wood	0.49 to 0.59
Fresh mortar	1.78	Oak	0.69 to 1.03
Dry gravel	1.8	Iron	7.8
Wet gravel	2.	Steel	8.
Clay	1.8 to 2.6		

The web of iron beams is usually double the flange, and flanges of 8, 10 and 12 centimeters are easy to get.

As the kerf is generally taken off timber sizes, they measure with remarkable accuracy in centimeters, as they actually are found for sale. The following table shows this. The first column is in inches, the second in centimeters, the third cubic centimeters per meter run. The last column may be read as decimeters or as fractions of a meter.

ACTUAL DIMENSIONS OF TIMBER, ETC., AS SOLD IN WASHINGTON, D. C.

Inches.	Centimeters.	Solid Contents Per Meter Run. (Cubic Centimeters.)
¼ by 12	0.6 by 30	1,800
⅜ by 12	1 by 30	3,000
½ by 12	1.2 by 30	3,600
⅞ by 12	2.2 by 30	6,600
1 by 2	2.5 by 5	1,250
2 by 2	5 by 5	2,500
2 by 3	5 by 7.5	3,750
2 by 4	5 by 10	5,000
2 by 6	5 by 15	7,500
2 by 8	5 by 20	10,000
2 by 10	5 by 25	12,500
2 by 12	5 by 30	15,000
3 by 3	7 by 7	4,900
3 by 4	7 by 10	7,000
3 by 6	7 by 15	10,500
3 by 8	7 by 20	14,000
3 by 10	7 by 25	17,500
3 by 12	7 by 30	21,000
4 by 4	10 by 10	10,000
4 by 6	10 by 15	15,000
4 by 8	10 by 20	20,000
4 by 10	10 by 25	25,000
4 by 12	10 by 30	30,000

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

GEOLOGY.

The last Annual Report of the Smithsonian Institution, for 1902, contains, among many other valuable articles, two of especial interest to the teacher of geology. The first is a "Preliminary Report on the Recent Eruption of the Soufriere in St. Vincent, and a visit to Mont Pelée in Martinique," by Tempert Anderson and John S. Fleet, being a reprint of an article published in the *Proceedings of the Royal Society, London,* Vol. LXX. The second article is on the "Volcanic Eruptions in Martinique and St. Vincent," by Israel C. Russell, and is a reprint of an article in the *National Geographic Magazine,* Vol. XIII. Both of these are very valuable papers, written in a readable, popular style easily used by the student and are assuredly accurate. The last contains in addition a bibliography of sixty-seven titles of magazine articles bearing on these eruptions; this last is a notable help as a source of reading and illustration. E. C. C.

BOTANY.

Influence of Radium on Plant Growth.—With a view of obtaining information regarding the sensibility of protoplasm toward the radiations of radium, Mr. Henry H. Dixon, distributed 100 cress seeds uniformly over the surface of some sand contained in a saucer. Then a tube containing 5 mg. of pure radium bromide was supported at a height of 1 cm. over the center of the sand. During the experiment the saucer was covered with a glass shade and was kept in the dark. After two days, germination took place nearly simultaneously all over the sand, the growth of all the seedlings being nearly uniform; but a close comparison showed that the seedlings immediately under the radium tube were retarded in their development to some extent. This retardation was apparent in the seedlings situated within a radius of about 2 cm. of the radium bromide. Besides being smaller, they developed fewer and shorter hair roots than those nearer the margin of the sand. The subsequent growth of the plants seemed to be in no way affected by the radium, nor did it appear to exercise any noxious effects, other than the retardation just described. The experiment was repeated twice with the same results. To determine if motile organisms are sensitive to the radiations, Mr. Dixon enclosed the radium in a tube

of water containing large quantities of Volvox globator. Extraneous light was cut off during the experiment. After twenty hours many of the Volvox colonies had sunk to the bottom of the vessel, but they were evenly distributed over the bottom, while those that were still swimming in the water were also uniformly distributed through it, some being in contact with the radium tube. None showed signs of being attracted to or repelled from it. These experiments indicate that the radiations emitted by radium bromide are not able to produce marked effects in a short time on these vegetable cells and tissues.

PHYSIOLOGY.

Typhoid Fever from Oysters.—Typhoid fever outbreaks due to oysters subject to sewage discharges continue to be recorded. A recent British parliamentary paper contains a report by Dr. Timothy Bulstrode, a local government inspector, on two such outbreaks. In each case oysters from the same source were served at mayoral banquets, on the same day, in towns some distance apart. After an interval some of the honorable mayors in each group went down with typhoid, but those who did not eat oysters escaped. The oysters were obtained from Emsworth from beds only a few yards away from the outlet of the main sewer.—*American Medicine.*

The French Campaign Against Alcoholism.—The Paris letter in the *New York Tribune-Review* for November 14 describes a grand popular movement inaugurated by the meeting of the first National Anti-Alcoholic Congress. French medical authorities attribute the present stationary condition of the population, in great measure, to alcohol. The French consume more alcohol per capita than any other people in the world. While the consumption of alcohol is steadily increasing, crime and suicide, in some parts of the republic, are increasing at a much more rapid rate. French publicists feel that they must face a greater problem than that which confronted Sweden in 1855. One of the first reforms to be demanded is the prohibition of the sale of intoxicants to children. The war against drunkenness will be waged on a large scale. Some of the statistical tables, diagrams, pictures, etc., prepared for this congress will be sent to the French section of the St. Louis Exposition.

Lectures to High School Students in Hygiene.—The Prussian minister of instruction has issued an order that four one-hour lectures on hygiene be delivered during the winter in eight of the Berlin high schools. The lectures have been chosen with great care and embrace the following subjects: (1) The significance of micro-organisms in the promotion of public health. (2) Nutrition with particular consideration of the alcohol question. (3) Individual hygiene with special notes on sports. (4) The

hygiene of mental labor and the care of the organs of sense. The three upper classes are to partake in these lectures, teachers and parents being permitted to be present also.—*Mind and Body*, June, 1903.

Health's Decalogue.—The Leader quotes the following from a French medical review:

1. Rise early, retire early, and fill your day with work.
2. Water and bread maintain life; pure air and sunshine are indispensable to health.
3. Frugality and sobriety form the best elixir of longevity.
4. Cleanliness prevents rust. The best cared for machines last the longest.
5. Enough sleep repairs waste and strengthens; too much sleep softens and enfeebles.
6. To be sensibly dressed is to give freedom to one's movements and enough warmth to be protected from sudden changes of temperature.
7. A clean and cheerful house makes a happy home.
8. The mind is refreshed and invigorated by distractions and amusement; but abuse of them leads to dissipation and dissipation to vice.
9. Cheerfulness makes love of life, and love of life is half of health. On the contrary, sadness and discouragement hasten old age.
10. Do you gain your living by your intellect? Then do not allow your arms and legs to grow stiff. Do you earn your bread by your pickaxe? Do not forget to cultivate your mind and to enlarge your thought.

Book Reviews.

Physical Laboratory Manual. By H. N. Chute, M. S. 13x19 cm. xi and 267 pages. D. C. Heath & Co. Boston, 1903.

Progress in physics teaching is taking place at such a rapid rate that every little while a new laboratory manual becomes necessary. Not all of the new manuals, however, are of a necessarily superior value. On the other hand, new editions of old and tested books such as the one under review can be hardly otherwise than good. The 1903 edition of Chute's Laboratory Manual is excellent in many respects and yet is not greatly different from the edition of 1894. Doubtless in 1894 Mr. Chute foresaw quite clearly the course the development of laboratory work would take. That one of Mr. Chute's wide and long experience should agree so well with himself after ten years is an encouraging sign in these days of strivings after novelties and fads.

The general appearance of the new edition is enhanced by the frequent use of bold faced type for the key words in many of the important paragraphs. Another good feature is the giving of sample numerical data in connection with the suggested tabular forms for the recording of results. Pupils can thus the more readily judge of the defect or excellence of their

own results and will the better know what is expected of them. Still another valuable feature is the way in which many experiments usually performed in a desultory, qualitative manner have been given rigidity and quantitative value by the statement of the object and the requiring of such data that something has to be measured or several things have to be compared instead of merely requiring the observation of a single phenomena in a fixed set of conditions. In this connection I would beg leave to suggest that experiments headed "To verify the laws," etc., and "To investigate the laws," etc., might be improved in a somewhat similar manner.

Some of the new features in the book of especial value, aside from the general improvement in the wordings of the directions for experimenting and interpreting, are these: The use of the Hawkes-Atwood machine for accelerated motion; the use of an automatic method for determining pendulum coincidences; the apparatus used to determine the coefficient of air under constant pressure; improved ways that are yet very simple for finding the frequency of a tuning fork; a more thorough study of magnetic phenomena; a much more extensive treatment of electrical experiments; the introduction of the potentiometer method and the use of standard cells. This method is sufficiently simple for elementary work and has a wider range of application than any other general method of electrical measuring. It is the practical method. It seems strange that it has not been used in high schools before. It might well displace all other methods for E. M. F., resistance, and current in an elementary course, excepting perhaps that other zero method, Wheatstone's bridge.

On the whole the book is very satisfactory and will doubtless be a standard for laboratory manuals for some time to come.

E. C. Woodruff.

Laboratory Manual of Biology. By G. W. Hunter and M. C. Valentine, Instructors in Biology, DeWitt Clinton High School, New York. 13x19 cm. vii and 215 pp. Henry Holt & Co. New York, 1903. 60 cents.

Laboratory Manuals on biology, botany or zoölogy are becoming almost as numerous as the instructors who teach these sciences, each new book partaking more or less of the personal equation of the particular man or woman who wrote it, and having, therefore, the good and bad points pertaining to the individual teacher. Therefore, when another manual is added to the list written by two New York teachers, it was to be expected that history would repeat itself. This, indeed, has occurred, but it must be admitted that the authors have made a creditable addition to the books on laboratory procedure.

Some criticism may be made on the work as a whole: that there are too many questions of the Yes and No type to be strictly justifiable; that numbers of the questions are rather trivial, not demanding sufficient mental response to be valuable, and that, finally, there is a large preponderance of purely observation questions as contrasted with those dealing with the rea-

son of things. This latter exception is, however, open to question, because the average pupil of the second year in high school may be adjudged the possessor of an amount of the reasoning faculty he does not have, and by reason of this false judgment many a manual question never hits the mark but is hopelessly lost in the tangle of imperfect understanding.

The method of treatment has much that commends it to the biological instructor. The note interpolation is, in particular, a good idea, as is the summary of drawings at the end, thus as far as may be encouraging note-taking before drawing. Part III on "The Excursions" and Part II on "The Experiments" are particularly helpful and suggestive and must do much to stimulate the latent observational and reasoning powers of the pupil.

H. S. Pepoon.

Studies in Physiology. By James Edward Peabody, A. M., Instructor in Biology, the Morris High School, New York City. The Macmillan Company, New York. 13x19.5 cm. xviii and 332 pages. 1903.

According to the author's preface, the book is intended to be read to supplement the work already done in the laboratory. Frequent reference is made to Peabody's *"Exercises in Anatomy and Physiology,"* the author's earlier laboratory guide.

The first three of the fourteen chapters of the text discuss the definitions and uses of technical terms necessary to the understanding of the processes and the general cellular structure of the animal body. Then follows a discussion of foods, the processes of digestion, which the author cleverly calls "A Study of Blood Manufacture," the blood and its circulation, the skeleton, muscles, respiration, the skin and kidneys, the nervous system, special senses, and the voice.

Since the text was expressly written for the use in high schools where physiology is taught with biology, there are frequent comparisons between the human and the lower animal organism. Abundant illustrations of these points add both interest and clearness to the text. At the close of each chapter there is a brief discussion of the hygiene of the subject considered.

All references to the use of alcoholic stimulants are either well chosen quotations from reliable scientific authorities or careful statements by the author himself.

Though there are occasionally too many details and too much that is not in direct connection with the subject in hand, as well as a lack of clear-cut conclusions to the illustrations and arguments, the text is generally accurate and written in a style attractive to the student.

Bernice L. Haug.

Reports of Meetings.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The third meeting of the association was held at the Northwestern Professional School building in Chicago on Friday and Saturday, November 27 and 28, 1903. At the general session on Friday morning, after the opening remarks of the president of the association, Mr. Charles H. Smith, addresses of welcome were given by Dean R. F. Holgate and by President Edmund J. James, of the Northwestern University. Of the various committees then appointed, one in particular is of general interest. The object of this committee is to arrange a plan of coöperation by means of which the members of the association may be aided in securing promotion and desirable changes of position.

Two addresses were given during the morning session. The first was by Dr. William Trelease, director of the Missouri Botanical Garden, on "The Articulation of High School and College." A memorandum of the address is as follows:

The speaker called attention to the instability of the present educational system of the country, extending practically from the kindergarten to the graduate school and depending on the varying demands made upon the system, owing to changing conditions of life and the experimental nature of many of the component parts of the system. Particular attention was called to the stress existing at the points of union of the preparatory school and college and of the college and professional school—largely because of administrative interruptions at these points.

Attention was called to the rapid evolution of the modern high school which the last decade or so has witnessed; to the rapidly growing number of university men holding the doctor's degree, on the instructional staff of these schools; and to the gradual but rapidly growing amplification of the work undertaken by the secondary schools. The results reached by the college entrance examination board in unifying entrance options was pointed out, and the rational need of extending this work so as to make the entrance options in science and the elementary college courses in the same as nearly equivalent as possible was shown.

The speaker quoted a statement, prefacing a resolution adopted by the National Educational Association at its Denver meeting, that "the most pressing need for higher education in this country is a better understanding between the secondary schools and the colleges and universities in regard to requirements for admission," stating that in his judgment this articulation point of high school and college was the most critical point in our existing system, and that the last half decade, if it had

changed the exactness of the statement quoted, had done so merely by making the omission of the one qualification in regard to requirements for admission desirable.

Closing as he had begun, by drawing attention to the mutation evident in the existing system, the speaker said that as a biologist he saw in this pliability the greatest encouragement for believing that the present system contained the elements of the system of the future, since biologists were generally agreed that those things which were fixed were inexorably discarded in evolutionary progress, variability characterizing all of those which subsequently gave rise to those that succeeded.

The second address was by Dr. Albert Perry Brigham, head of the department of geology and natural history, Colgate University, his subject being "The Fruits of Science Teaching." The address is given in full on page 367, *et seq.*, of this number.

The afternoon was devoted to meetings of the five sections of the associations. Reports of these section meetings will be published later.

In the evening a general meeting was held to discuss the question, "Is Not the Law Prescribing the Teaching in Public Schools of So-Called 'Temperance Physiology' a Hindrance (1) to Education, (2) to Temperance?" The discussion was opened by Dr. Winfield S. Hall, professor of physiology, Medical School of Northwestern University; Rev. M. M. Parkhurst, D. D., general superintendent of the Citizens' League; and Prof. James H. Armstrong, principal of the Englewood High School. A spirited discussion participated in by a number of the members of the association then followed, at the close of which a committee was appointed to draw up a set of resolutions in regard to the question to be presented at the general session, Saturday morning.

On Saturday morning meetings of several sections were held until 11 o'clock, when all came together for the third general session. The following officers of the association were elected for the ensuing year: President, Charles H. Smith; secretary, C. E. Linebarger; treasurer, E. C. Woodruff. The resolutions of the committee on "Temperance Physiology" were adopted. They are as follows:

WHEREAS, The states represented in the Central Association of Science and Mathematics Teachers all have laws requiring the teaching of physiology and hygiene with special reference to the nature of alcoholic drinks and other narcotics, and

WHEREAS, We believe that the method of presentation required by these laws makes such teaching detrimental to the best interests of both education and temperance, and

WHEREAS, We heartily favor every wise effort to do away with the evils which result from the use of alcoholic liquors and narcotics and desire to coöperate with the agencies that are working to eradicate these evils, therefore, be it

Resolved, That a commission of five be appointed by the chair to

investigate this whole matter, to make a definite report, and to present recommendations at the next annual meeting of this association.

J. E. Armstrong,
H. N. Goddard,
H. L. Roberts.

An address was then given by Dr. John Dewey, professor of philosophy and education, and director of the School of Education, University of Chicago, on the "Disciplinary Value of Science Teaching," an abstract of which follows:

After defining discipline as consisting in exercise and instruction in certain subjects in order to secure efficiency in those subjects, the speaker pointed out that this defintion conflicts with the conception known as "formal discipline." According to the doctrine of formal discipline, exercise and instruction in the same subject may serve to generate power in other directions which are more comprehensive and fundamental. Thus the doctrine of formal discipline holds that by training memory as to the spelling of words the *faculty* of memory is also trained; that through training students to attend to a text or to the teacher for recitation purposes the power of attention at least is built up.

The speaker called attention to some experimental work which had been done by Doctors Thorndike and Woodworth, showing that as a matter of fact great increase of proficiency in the exercise of some one mental function may be secured with relatively little improvement in other closely allied functions. For example, persons may be trained to judge the dimensions of triangles with great rapidity and accuracy, without anything like an equally marked improvement in ability to judge dimensions of, say, rectangles.

From this point was developed the notion that the aim in science teaching ought to be ability to think logically and scientifically: that is, to control all mental operations that have to do with the discovery of truth, and with the testing and development of all relevant ideas. The speaker indicated his belief that in this sense the discipline which comes from scientific teaching and general intellectual discipline (or command of mental powers) are one and the same thing. From this point of view it follows that if the disciplinary results of science teaching are unsatisfactory, it is because teachers are endeavoring to secure power of thinking by other means than the actual present exercise of the same kind of thought activity that forms the goal in view.

The speaker pointed out three essential elements in ability to think scientifically, or to control powers of inquiry. These were: (1) Observation, (2) mastery of a large amount of relevant information, and (3) ability in experimental manipulation. The educational problem of discipline depends upon whether the observation, accumulation of information and acquisition of experimental technique respectively are made ends in themselves, or are employed in subordination to grasping and following out

some intellectual problem. In the latter case we have reason to expect that real intellectual discipline will result. In the former we are merely getting increased proficiency, of a gymnastic sort, in the particular thing in which the students are trained. That is, the student *may* learn to observe without gaining anything excepting increased power to make more observations of the same kind. He *may* learn to accumulate and memorize information without getting any ability excepting that of doing more of the same kind of memorizing; so also he may become highly proficient in the technique of experimentation without getting anything more out of his training than power to manipulate apparatus. The student not only *may* do this, but he *will* do it, unless he sees some relation between his present observation by getting hold of relevant knowledge, and performing his experiments, and the entertaining and solution of some genuine thought-problem. If students are not through their science teaching gaining general power to think in an independent, orderly and systematic way, it is because they are not being consciously exercised in this same kind of thinking at every step of their educational progress.

The bane of science teaching as well as of other branches of instructions is the acceptance, unconscious if not formal, of the doctrine of formal discipline: the belief, that is to say, that exercise in scientific thinking may be postponed until the student has got power to observe; has accumulated through lectures and text books a sufficient amount of information about the topic he is pursuing, and has been trained in the modes of laboratory procedure.

There is absolutely no miracle of spontaneous generation in the mental any more than in the physical realm. The postponement of thinking simply leads to the formation of habits which are isolated from thinking. Thus the perfecting of skill in the various directions alluded to not only does not tend toward discipline in scientific thinking, but actually retards such progress. On the other hand, a reform in science teaching which should subordinate every other school exercise to power to think could not fail to bring about in its wake a reform in *all* methods of school instruction.

Saturday afternoon was given over to excursions, one being to the Illinois Telephone Company and another to the Illinois Steel works.

UPPER PENINSULA (MICH.) EDUCATIONAL ASSOCIATION.

Upper Peninsula educators may well be proud of the enthusiastic association meeting held at Marquette, October 29-31 last. Over five hundred members and a great many visitors were in attendance. The general sessions were held in the audience room of the new High School building, which room Prof. A. S. Whitney, of the University, pronounced the most perfect among the hundreds he has visited. The evening sessions at the Opera House were addressed by Prof. R. D. Salisbury and Dr. George E. Vincent, of the University of Chicago. These addresses on "The Making of the Great Lakes" and "The Mind of the Mob" were highly entertaining and more. They were masterly presentations of geographical and psychological problems that were revelations to the teachers of the possibilities of these subjects.

The section meetings were held at the Northern State Normal School, the science section convening in the biology laboratory at Peter White Hall of Science. The following is the program:

Chairman—Prof. E. R. Downing, Northern State Normal.

General Topic—"Nature Study in the Grades":

"The Ends to Be Achieved and the Principles to Be Observed in the Teaching of Nature Study," Lincoln M. Rutledge, Principal Washington School, Calumet.

Discussion—Supt. J. F. Walker, Republic.

General Discussion, Open to All—

"When and How Shall Physics and Chemistry Be Taught in the Grades?" F. C. Bohannon, instructor in science, High School, Iron Mountain.

"When and How Shall Animal and Plant Study Be Taught in the Grades?" Supt. A. D. DeWitt, Newberry.

"The Correlation of the Nature Work in the Grades and Science Work in the High School," Miss Ermina B. Smith, teacher of eighth grade, Menominee.

Discussion—"Sequence of Topics and Methods in Teaching Nature Study." To be opened by Mr. Charles E. Dull, instructor in science, Negaunee High School.

Mr. Rutledge's paper, to be published in SCHOOL SCIENCE, was a plea for nature study, for its intellectual, its æsthetic and its ethical value. Careful arrangement of subject matter suited to the various grades, out-of-door work in abundance and enthusiastic leadership were among the important principles insisted upon.

Mr. Bohannon and Mr. DeWitt agreed that work on the living material should have precedence in the lower grades. The former outlined a course in the elements of physics and the chemistry of common things which is

found practicable in Iron Mountain schools. Mr. DeWitt advocated even the use of the microscope in the grades in an attempt to make vivid impressions of nature's marvels.

Mr. Dull in opening the final discussion took the position that frequently teachers, because they lack knowledge of the subject, dislike the nature study period, so that it is worse than useless. He advocated a very cautious introduction of nature study until the teachers themselves were adequately instructed. He thought the child's mind is adapted to memorizing rather than reasoning and that the nature work should aim to supply information and not try, by experiments, to follow cause and effect.

The discussions developed the fact that the nature study courses given in the graded schools of the Upper Peninsula are widely variant. The section therefore appointed a committee to coöperate with a similar committee appointed by the superintendent's section, at the request of the science section, in formulating a uniform course of nature study for Upper Peninsula schools. This will be reported to the science section at its next meeting.

Reported by E. R. Downing

NEW YORK ASSOCIATION OF BIOLOGY TEACHERS.

The first meeting of the association for this school year was held at the Girls' High School, Brooklyn, November 20, 1903. The program for the evening consisted of a discussion of practical school problems. Mr. H. E. Chapin spoke upon the topic, "Museum and Field Work." He said in part:

The frequency of excursions to field and museum depends largely upon the number of teachers in a school. It is well to offer an opportunity for this kind of work about once a week. The best time is Saturday. The advantages of Cold Spring Harbor as a collecting ground were pointed out; also the advantages of the Zoölogical Park and the American Museum of Natural History. In closing emphasis was laid upon the fact that field and museum work ought to be required.

Mr. Roy Spencer Richardson read a paper upon "The Collection and Preparation of Biological Material for Study." Mr. Richardson is a practical biologist and gave the association the benefit of his experience as a collector in the vicinity of New York, and in addition outlined many simple and valuable methods of preparing the material for study. The paper was of great importance to all teachers of New York and vicinity, as many nearby localities were pointed out at which various animals and plants could be found in abundance. His methods of killing animals in an expanded condition and of preserving them had all been tested and he exhibited several specimens to show their success.

Mr. Frederic Bement discussed briefly "Methods of Teaching Protozoa." His remarks were confined to the common forms usually studied in the laboratory. He said that in his experience he had found it more profitable to begin the subject by a brief study of the animals from a chart or textbook, paying particular attention to the structures to be studied later in the specimens. After the pupil had thus obtained a working knowledge of the forms he was given the specimens for study under direction of an outline.

The program for the evening closed with a paper by Dr. Philip Dowell upon "Note-books and Note-taking." The importance of correct habits was first emphasized. This was followed by an analysis of various deficiencies commonly found in note-books, with suggestions as to remedies.

Reported by FREDERIC BEMENT.